Research Project

04-5GT

C a p s u l e

LTRC

Technology Transfer Program *May 2005*

Control of Embankment Settlement: Field Verification of PCPT Prediction Methods

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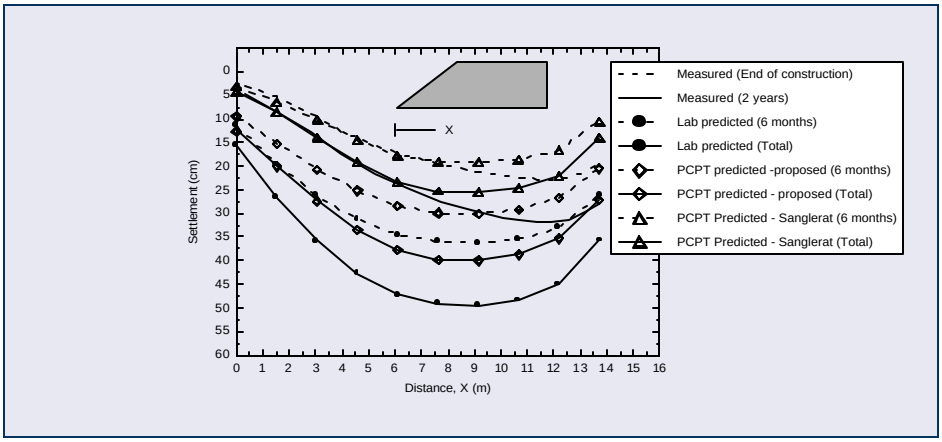
Problem

Saturated fine-grained soils, when loaded, can undergo large consolidation settlements over a long period of time. Since this type of soil deposit is common in southern Louisiana, the construction of embankments, bridges, and other structures requires a reasonable estimate of the magnitude and time rate of the soil's consolidation settlement. This estimate is essential to prevent the bumps that often occur at the embankment bridge approach.

Currently, the consolidation characteristics of cohesive soils are estimated from laboratory test results on samples collected from the field by conventional drilling methods (i.e. hollow-stem augers, mud-rotary drilling, etc.) The piezocone penetration test (PCPT), an in-situ test, is a valuable tool for subsurface investigation because it is simple, fast, and economical. The PCPT collects soil and porewater information via computer throughout the entire depth penetration. This detailed data is valuable for a wide range of geotechnical engineering applications.

LTRC project 00-3GT evaluated the current PCPT interpretation methods for their capability to reasonably predict consolidation parameters. The results of this study demonstrated that the consolidation parameters—constrained modulus (M), overconsolidation ratio (OCR), and vertical coefficient of consolidation (cv)—can be reasonably predicted from the results of piezocone penetration and dissipation tests. These parameters can be used to predict the magnitude and time rate of consolidation settlement for normally and lightly overconsolidated cohesive soils. In addition, the predicted total settlements from PCPT data were more reliable and accurate than the traditional laboratory predicted rate of settlements.

The study recommended that the LA DOTD engineers gradually start to implement the PCPT technology, particularly to estimate the consolidation settlement of fine-grained soils, in conjunc-



Comparison of PCPT-predicted, laboratory-calculated, and field-measured settlements for the LTRC test wall

tion with the traditional laboratory calculation of settlements. The study recommended that the comparison of the consolidation settlements predicted from the PCPT data, the calculated settlements from laboratory consolidation parameters, and the field-measured settlements be continued until the LA DOTD engineers build enough confidence in the PCPT interpretation methods. With increasing confidence and experience, LA DOTD engineers can move toward replacing conventional subsurface exploration with piezocone penetration and dissipation tests with the estimation of consolidation settlement.

The previous study was based on limited sites and therefore recommended that the proposed relations estimating the constrained modulus (M) and the overconsolidation ratio (OCR) from PCPT data be validated. The Teh and Houlsby method used to estimate the vertical coefficient of consolidation (cv) should also be validated by comparing the measured values at new selected sites with the predicted values obtained from the proposed relations. The research recommended the development of a computer program to profile the consolidation characteristics of soil layers with depth, and to facilitate the use of the PCPT methods to estimate the magnitude and time rate of settlement of fine-grained soils.

This project, 04-5GT, will validate the previous study with additional sites, providing more confidence prior to full implementation. This project will also develop the computer model and verify the PCPT prediction methods with several field sites. The constrained modulus of each soil layer can be estimated using the PCPT data (qc, u1), while the coefficient of consolidation can be estimated from the piezocone dissipation curves obtained at different penetration depths. The development of this program will examine the possibility of using soil properties and measured pore pressures to predict a continuous profile of the vertical coefficient of consolidation (cv) with depth and to detect thin drainage layers. It is anticipated that implementation of the PCPT methods, in the long run, will result in a cost benefit and an improvement in settlement prediction.

Objectives

The objectives of this study are (1) to develop a Visual Basic program to estimate the consolidation settlement of embankments using PCPT data and input from the user, and (2) to verify and calibrate the findings of the initial research, 00-3GT: Control of Embankment Settlement, with additional field sites, by comparing the measured field settlement profiles with depth to both PCPT-predicted settlements (via the Visual Basic Program) and laboratory-calculated settlements.

Description

At least five embankment sites throughout Louisiana will be instrumented with horizontal inclinometers, magnet extensometers, and settlement plates to monitor the consolidation settlement with time. Prior to the construction of these embankments, field samples will be collected and tested, and in-situ piezocone tests will be conducted. The consolidation parameters will be determined and used to calculate the total consolidation settlement and time rate of consolidation settlement for the embankments. The laboratory calculated and measured settlement will be compared against the PCPT-predicted settlements.

This comparison will allow three settlement values (two calculated and one measured) per site to verify and/or calibrate the findings of the original study, improve accuracy and precision, and serve as test sites to evaluate the computer program.

Simultaneously with the field monitoring, work will begin on developing a Visual Basic computer program to be used by DOTD design engineers. The program will allow users to input field and site parameters, reference a PCPT data file, and use engineering judgment to estimate settlement at embankment locations. Only the recommended PCPT settlement prediction methods will be implemented in this program.

Implementation Potential

Utilizing the PCPT data to estimate settlements will benefit the department by providing:

- Faster estimates, since the in-situ test data will be read by the computer program.
- Easier calculations, since the computer program will perform most of the operations.
- Lower labor costs, since crew sizes, sample quantities, and the number of laboratory tests are reduced when using PCPTs.
- Higher confidence in our previous research (00-3GT), since more sites will be analyzed. This research will confirm the best methods for using PCPT data to estimate the total consolidation settlement and rate of consolidation settlement.
- User-friendly Visual Basic software will facilitate the implementation of PCPT technology to estimate embankment settlement.